Small Lot Intelligent Manufacturing Workshop Abstracts
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Small Lot Samples for Binary Testing Using Bayesian Techniques

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This presentation outlines the results of an investigation into developing sampling plans for small populations. In industrial testing, it is desired to assess the high reliability of products for quality assurance purposes and samples are routinely pulled from either production lines or from storage lots. In this testing process, the number of samples is required to be at a minimum to keep the costs down while still achieving a desired level of confidence. Many sampling plans have been proposed and compared in the literature for this purpose. This presentation documents an alternative approach based on an extension of the method outlined by Martz and Waller (1991). Specific sampling strategies are developed under the assumption that a hypergeometric distribution characterizes the underlying defect rate of the small population. We also assume that some historical knowledge of the reliability of the product has been accumulated from previous testing on similar equipment. In the presentation, we will discuss and compare different testing sizes while controlling classical, average and the posterior Bayes risks with varying number of failures. We will discuss the meanings of these risks and show that the Bayesian approach for the posterior risks allowed the smallest sample sizes.

Assuring High Reliability in Small Lot Production

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Manufacturing philosophy in the nuclear weapons complex has shifted dramatically from the regular production and delivery of large orders to less frequent small orders. New weapons components are produced less frequently and in smaller quantities. The challenge is to build much smaller lot sizes while maintaining the same high reliability standards. A key component of this challenge is to assure reliability given few actual performance tests of the final product. Current reliability assurance methods emphasize final product tests in simulated or actual weapon use environments. A large number of tests for each major component within the weapon is necessary to confirm the weapon reliability. In a small lot production environment with a limited number of product tests, the current methods are not viable. What is needed is a reliability assurance methodology that correlates information from the manufacturing process, including sub-component inspection and testing, to end use reliability. In this paper we present an approach to reliability assurance that relies on such manufacturing data to assure reliability with limited end product testing. To demonstrate this approach a case study involving the production of neutron tubes is presented.

Smart Machining Research at NIST

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This talk will summarize collaborative research at the National Institute of Standards and Technology (NIST) in the area of enabling metrology and standards to achieve “smart machining” operations and how these concepts and results apply to small lots manufacturing. Machine tools, such as lathes and milling machines, are critical in the manufacture of products, ranging from consumer goods to airplanes. Moreover, improvements in machine tools and machining processes have a highly leveraged impact on the economy and national security, enhancing productivity and product quality while enabling more complex products to be manufactured. Users of machine tools, though, are faced with numerous challenges, such as ever-more complex parts, tighter part specifications, shorter lead times, and smaller batch sizes. Success requires accurate and reliable machines whose performance is known and guaranteed for a wide variety of tasks and operating conditions. However, machine tools are subject to many error sources that change over time, are difficult to assess or predict, and are task specific. Furthermore, the machining process is complex and difficult to optimize. So users often resort to costly and time-consuming trial runs, regular part inspections, and on-going adjustments to achieve requested part accuracies and process efficiencies. Productive, high-quality manufacturing will increasingly rely on smart machines that benefit from a thorough understanding of the science of the machining and are able to exchange accurate, complete information about their operation and status with machine operators, product designers, and other machines. NIST activities in the areas of machine tool metrology, manufacturing process metrology, open architecture control, condition-based monitoring and maintenance, and smart sensor systems will be addressed, as well as how these contribute to a future vision of a smart machine tool.

Intelligent Wireless Technology – Agility, Mobility, and Security

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The industrial wireless technology marketplace is exploding. Almost everyone who sells any type of sensor is now marketing a wireless variety. What does all this mean and where is it all headed? Clearly wireless technology is the biggest thing to hit the industrial automation marketplace since the microprocessor. Combining wireless with the new "agent" technology offers the potential of a completely new type of "distributed intelligence" and significantly more impact than either one alone. My discussions will center around what's going on industry, what's coming from the suppliers, and what impacts these emerging technologies might have on small lot intelligent manufacturing. I will also discuss a little of the history, pitfalls, and likely future developments. I will pay particular attention to distributed intelligent sensor networks, security, and leveraging technology from the commercial (communications) marketplace for use in manufacturing.

Using Cost Effective Methods to Manufacture Products in Small Quantities

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The application of computers to manufacturing processes and manufacturing control function is often considered as the most significant accomplishment that has been achieved since the introduction of the "Interchangeable Parts" by Eli Whitney in the late 1700's. The modern view of manufacturing encompasses all activities necessary to transform materials into a product in the field. One of the major concerns in the production of discrete parts is the elimination of non-value added costs, setup costs; work in process costs, etc. Reduction of these costs become a more significant issue when they are produced in a job shop environment.

The Cellular manufacturing concept was introduced in the late 1970's as a cost effective alternative to make a reproduction run of low volume, high variety parts. A similar concept is also employed to group the machines based on several operational characteristics. Part families are then assigned to various machine cells based on requirements and plans.

Despite the effectiveness of several cell formation methods developed by the principal investigator and others, the complicated nature of problem formations and solution methodologies make the applications of these techniques cumbersome and less attractive, specifically for small and medium sized manufacturing facilities.

The primary objective of this presentation is to introduce and examine several new methods to economically manufacture products in small quantity.

Implementing low cost flexible production platforms

Timothy Toogood

Procter & Gamble

"Procter & Gamble has companies on the ground in about 80 countries and our products are sold in more than 140 countries, yet we estimate we serve only about 2 billion of the worlds 5.5 billion consumers. Our first world manufacturing platforms are very expensive and relatively inflexible. Product cost is historically reduced by improving speed of product manufacture and process reliability. Product diversity is limited due to common needs of consumers in first world countries resulting amongst other things from a relatively limited interaction with the environment and the reach of mass merchandizing. Future growth of multinationals is increasingly dependent on successful penetration of third world markets. The environmental diversity and more direct contact with the environment by consumers in these markets results in a much broader array of consumer needs and niches that must be met with the next gen! eration products targetted for these regions. In addition the lower per capita income in these regions mandates that these broader array of product needs must be delivered at a significantly lower product price. Current first world manufacturing platforms are not up to the task of providing third world consumers with the product performance and diversity they require for a price they can afford. A significant portion of Procter & Gambles effort today is focused on using innovation methodologies and tools such as TIPS to engineer the type of low cost flexible production platform that can meet the demanding needs of third world consumers at a price they will be willing to pay."

Model Based Business Workshop

Lisa Vernon
Kansas City Plant

An overview of the Kansas City Plant's Model Based Business (MBB) Workshop will be presnted. The MBB, hosted by the Kansas City Plant's Science Based Manufacturing organization is a 3-day "hands-on" experience in the latest techniques used for the analysis, simulation, engineering, design, manufacturing, inspection and acceptance of mechanical and electronic product at the Kansas City Plant.

The MBB Workshop goal is to facilitate model-based business across the Nuclear Weapons Complex (NWC) by demonstrating current KCP model-based tools and processes available to all of our NWC and Industry Partners.

Applying simulation tools toward small lot production processes

Brent Hower
Kansas City Plant

The use of simulation tools in evaluating manufacturing processes has made it possible to understand the variables with limited or no prototyping. The use and value of these high-powered tools in the design space is well understood. The benefits in a production environment are the understanding of the important process variables, high yields, and the overall confidence in part fabrication. This discussion will review the benefits toward applying traditionally simulation design tools in a production environment with examples and known deficiencies

Science Based Manufacturing at the Kansas City Plant

John Engel
Kansas City Plant

Science based manufacturing is KCP's strategy for using scientific, engineering, and computational tools to allow rapid realization of product to support the nuclear weapons stockpile. Advanced computer aided design
tools are being used to interrogate 3D models of piece parts and product assemblies prior to entering the manufacturing process. Thus, building confidence our ability to build it right the first time--as well as supporting the concept of low-cost small-lot manufacturing. It is well known that modifications to a product's design before the chips start flying will reap cost savings and cycle time reductions throughout the product life cycle. Tolerance analysis, assembly analysis and rapid prototyping all support this concept.

Small Lot Electronics Manufacturing

Lee Hoover
Kansas City Plant

Small lot electronics manufacturing brings many challenges. This presentation will deal with capturing of requirements, component selection, procurement and acceptance as well as manufacturing planning and executing. Utilization of simulation, modeling and physical testing will also be discussed.

POSTER SESSION

Fuzzy Statistical Process Control for Small Lots

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The results of two separate studies are presented in this poster session. One using measurement data for beryllium exposure, but which would apply equally well to quality control. The other study used attribute data for quality control of the manufacturing of beryllium parts. Beryllium manufacturing at Los Alamos was chosen as the process to study because the manufacturing process is atypical. The process is atypical because it is almost always small lots and often a different part is processed each time. In both cases a computer model of the plant was used for the study. This was because the study was done prior to the actual operation of the Los Alamos plant. The idea was to compare fuzzy statistical process control (SPC) techniques with standard SPC techniques for atypical cases. The typical SPC method for dealing with measurement data is use X Bar-R charts. These charts work well with one input variable, but the beryllium plant operation must consider several variables. The normal procedure with multiple input data is to apply a least-squares technique to regress the multiple data to one input and the use the X Bar-R chart. The fuzzy technique uses rules and membership functions to reduce the multiple variables to a single variable and then apply the X Bar-R chart. In our study the fuzzy technique proved superior.

Our quality control study utilized attribute data, which is usually binary. It is usually a pass-fail situation. The standard SPC technique is to use a p-chart based on the binomial distribution. In our case we have multiple classifications like: firsts, seconds, recycle, and discard. The standard SPC method of dealing with this problem is to use a generalized p-chart based upon the chi-square distribution. The fuzzy approach to this multiple input problem is to use fuzzy rules to combine the multiple variables and then use a fuzzy chart that is somewhat similar to the standard p-chart technique. In this study the fuzzy method proved slightly superior and much easier to use than the standard generalized p-chart.

Information Integration for Small Lot Manufacturing Assessments

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By definition, small build manufacturing does not have the data rich environment necessary for assessing quality through post-production data analysis by such techniques as statistical process control (SPC). To assess quality for lots sizes as small as six or even one, all available information about the product, its constituents, its manufacturing processes and steps must be utilized. Information integration methods can provide the tools for how to gather, combine and estimate the uncertainties attached for this assessment. Information can be in the form of expertise of the product designers and manufacturers, experience from similar products and manufacturing processes, and in-line information gathered during the manufacturing steps, such as from sensors. A simple example is presented to illustrate how information from these sources can be combined in assessing quality of small lot manufacturing. The example begins with an assessment using information available prior to any prototype or manufactured product and illustrates how that initial estimate can be updated with new information.

Strategy for Small-Lot Manufacturing: In-Process Monitoring and Control

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The Cold War weapons complex produced thousands of components each year to support the stockpile. The manufacturing process stream consisted of unique combinations of equipment, people, processes, and plant idiosyncrasies with high first-time product yields. The qualification and re-qualification of processes relied on extensive inspection and destructive testing. Certification of product in part assumed that the manufacturing process stream was operationally stable and within specified sampling norms, i.e. manufacturing process remained consistent with design intent. The manufacturing process streams were reasonably well characterized in terms of inputs and outputs, but were otherwise treated as black boxes whose internal process dynamics were poorly understood. For the era in which it existed, this method of manufacturing, process qualification, and product certification was fully adequate and served the Nation well for four decades. The current LANL manufacturing approach is based on best effort: it tries to recreate as best as possible the original manufacturing stream, but on a smaller scale with much lower production volume. Here, we will explain why this approach is problematic for small production volumes and outline, through a real example, a modern approach to quality manufacturing by process monitoring and control in real time.